

REMARKS

Claims 1-16 are pending in the application, and all the claims are rejected.

Claims 1 and 2 are amended to recite that the molecule or atom to be introduced into the introducing site is generated from material other than the graphite-like layered material, and the molecule or atom to be introduced into the introducing site is contacted with the graphite-like layered material for introduction. Support for the amendment may be found, for example, at page 9, lines 13-17, which describes that when introducing a C₂ molecule, the C₂ molecule may be obtained by decomposing a hydrocarbon molecule such as ethylene or acetylene by means of a plasma or the like. Therefore, as an example, the C₂ molecule which is introduced constitutes the graphite-like layered material, but is generated from material other than the graphite-like layered material.

No new matter is added. Accordingly, entry of the Amendment is respectfully requested.

Response to Claim Rejection Under 35 U.S.C. § 102

Claims 1-16 are pending in the application, and are rejected under 35 U.S.C. § 102(b) based on Cohen et al. (U.S. Patent No. 5,993,697).

Applicants respectfully traverse, at least for the following reasons.

Independent claim 1 recites:

A process for preparing a reactive graphite-like layered material, which is a mono- or multi-layered material having a hexagonal main framework with chemical reactivity, from a graphite-like layered material referring to a mono- or multi-layered material having a hexagonal main framework comprising the steps of:

binding atoms having a dangling bond together with each other which are adjacent to a vacancy included in said graphite-like layered material, for reducing the number of dangling bonds in the vicinity of said vacancy to form an introducing site;

introducing a molecule or atom constituting the graphite-like layered material into the introducing site; and

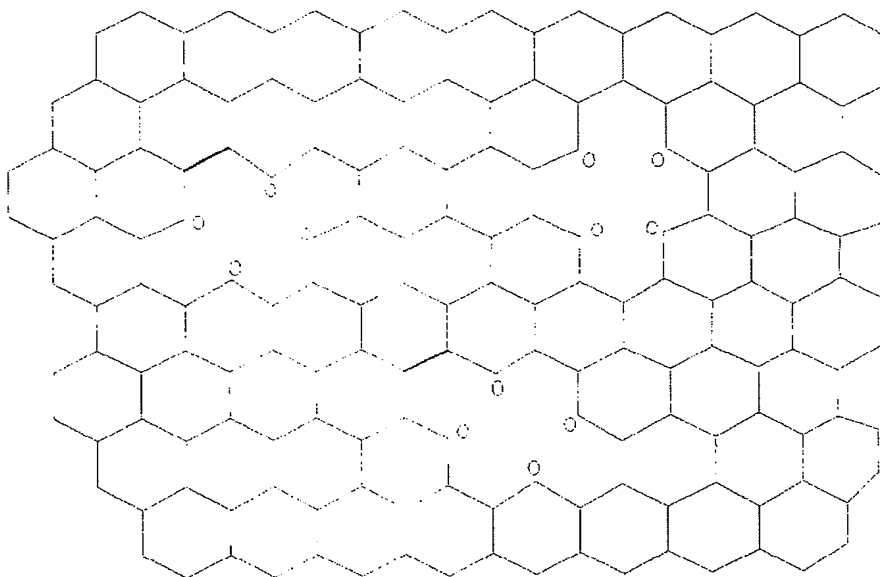
generating a new bond between the introduced molecule or atom and the graphite-like layered material,
wherein the vacancy included in said graphite-like layered material is formed in the shape of a diatomic vacancy or a monoatomic vacancy by detaching two adjacent atoms or one atom away from the graphite-like layered material, and
the molecule or atom to be introduced into the introducing site is generated from material other than the graphite-like layered material, and
the molecule or atom to be introduced into the introducing site is contacted with the graphite-like layered material for introduction.

Independent claim 2 of the present application uses analogous language.

The process of the present invention is directed to preparation of a reactive graphite-like layered material, in which Stone-Wales type defect sites composed of two pentagons and two heptagons, as shown in Fig. 5 of the present specification, or defect sites being formed in nine-membered ring shape, as shown in Fig. 6 of the present specification, are dispersedly embedded in the hexagonal network of graphite-like layered material. Thus, a periodic network of pentagons and heptagons is by no means constructed with the defect sites that are prepared by the process of the present invention. Furthermore, the Stone-Wales type defect sites formed in the process of the present invention that are embedded in the hexagonal network of graphite-like layered material may independently have three different orientations, the formation of which is described as follows.

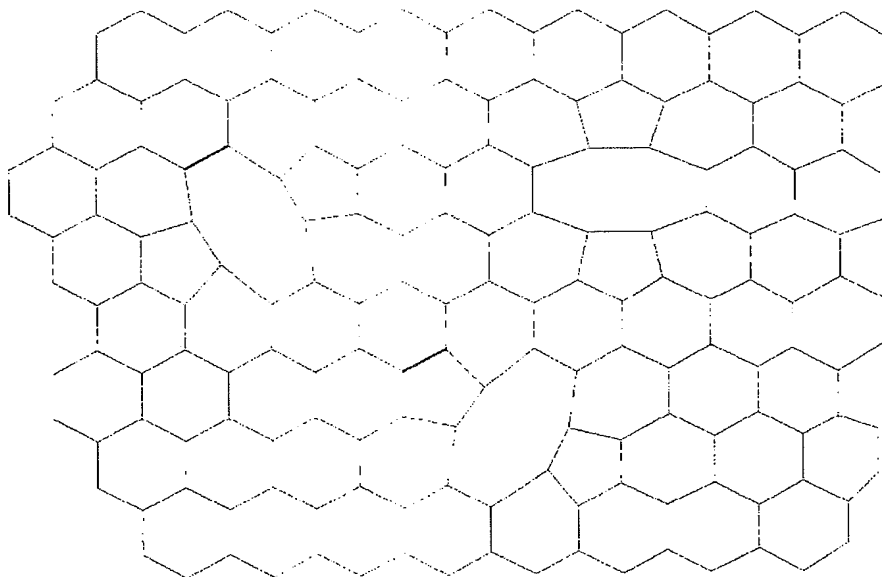
In the process of the present invention, the following four steps are sequentially conducted:

At the first step, plurality of vacancies is depressively formed in said graphite-like layered material, as illustrated in the following schematic sketch:



For instance, the plurality of diatomic vacancies, as illustrated in the above sketch, is formed by detaching two adjacent atoms from the graphite-like layered material. Thus, three types of diatomic vacancies are formed corresponding to the three types of the orientation of the two adjacent atoms (e.g. C=C) detached. The two adjacent atoms (e.g. C=C) detached are removed far away from the graphite-like layered material.

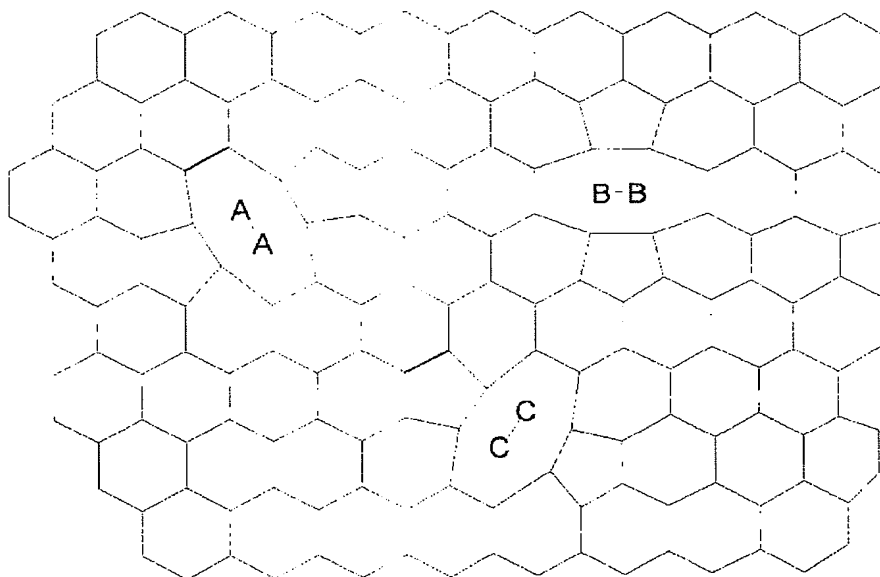
At the second step, plurality of introducing sites is formed from the plurality of vacancies:



As illustrated in the above sketch, three types of introducing sites having different orientations are formed corresponding to the three types of the orientation of the diatomic vacancies.

Accordingly, the introducing sites being formed in eight-membered ring shape are dispersedly embedded in the hexagonal network of graphite-like layered material. The second step for binding atoms adjacent to said vacancy together with each other to form an introducing site is carried out by means of structural relaxation, such as thermal annealing.

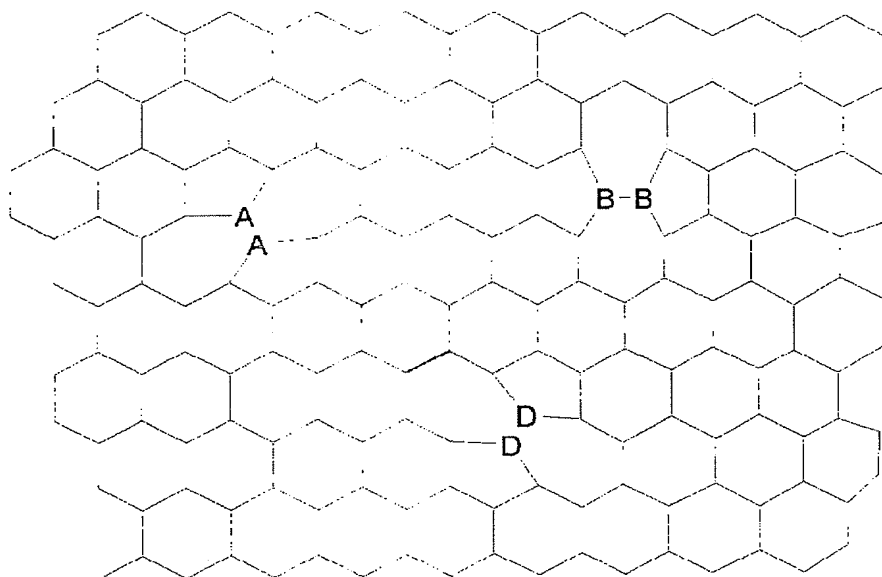
At the third step, the diatomic molecule (for example, C_2 molecule) to be introduced into the introducing site is generated from material other than the graphite-like layered material (for example, $CH_2=CH_2$) by means of vapor phase reaction, and then the generated diatomic molecule (for example, C_2 molecule) is introduced from vapor phase into the introducing site:



Plurality of diatomic molecules (shown by A-A, B-B, C-C) migrates on the surface of the graphite-like layered material having the plurality of introducing sites, and then each of the diatomic molecules (shown by A-A, B-B, C-C) is trapped in the introducing site, as shown in the above sketch.

At the fourth step, a new bond between the introduced diatomic molecule (shown by A-A, B-B, C-C) and the introducing site present in the graphite-like layered material is generated to construct a meta-stable Stone-Wales type defect site which comprises two 5-member rings and two 7-member rings.

Therefore, the defect sites of Stone-Wales type formed in the process of the present invention that are embedded in the hexagonal network of graphite-like layered material may independently have the following three different orientations as shown below, i.e., the orientation of the site indicated by A-A is quite different from the orientations of the site indicated by B-B or of the site indicated by D-D:



Additionally, the third step for introducing the diatomic molecule into the introducing site is carried out at such temperature cooled down from the thermal annealing temperature of the second step. After that, heating up to the thermal annealing temperature of the fourth step is conducted. The fourth step for generating the new bond between the introduced diatomic molecule and the introducing site to construct such meta-stable Stone-Wales type defect site is carried out by the means of structural relaxation, such as thermal annealing. Moreover, in the fourth step and the second step, photo-excitation may be employed as the means for structural relaxation in place of thermal annealing. On the other hand, in the case if photo-excitation is employed as the means for structural relaxation, the third step is carried out at the cooled-down temperature without photo-excitation.

As the Stone-Wales type defect sites, as shown in Fig. 5 of the present specification, or defect sites being formed in nine-membered ring shape, as shown in Fig. 6 of the present specification, are embedded in the hexagonal network of graphite-like layered material, these defect sites are metastable but more reactive than the original hexagonal conformation. Indeed,

the defect sites that are embedded in the hexagonal network of graphite-like layered material retain somewhat distorted ring shape in comparison with the totally relaxed ring shape of the periodic network of pentagons and heptagons, as shown in Fig. 1 of Cohen.

Cohen fails to teach such a process for preparing a reactive graphite-like layered material, in which a periodic network of pentagons and heptagons is absent, i.e., Cohen teaches a process for preparing pentaheptite that is essentially based upon the simplest possible way of tiling a plane with a periodic network of pentagons and heptagons, as show in Fig. 1, whereby:

graphite sheets in the form of hexagonal network are used as a starting material;

electron beam is directed along the plane of the graphite layers;

electron beam imparts energy to two adjacent carbon atoms in the lattice causing the two adjacent carbon atoms to rotate in-plane and convert a region of four hexagons into a region of two pentagons and two heptagons, as illustrated in Fig. 3 of Cohen, without destroying the material by ejecting atoms from it; and

the thus-resulted regions of two pentagons and two heptagons that are formed in the network shape are subsequently relaxed into the periodic network of pentagons and heptagons without any treatment of annealing.

The process disclosed in Cohen does not employ such a condition that a molecule (for example, a C₂ molecule) to be introduced into the introducing site is generated from other material than the graphite-like layered material (for example, CH₂=CH₂), and is contacted with the graphite-like layered material for introduction. The process disclosed in Cohen employs only such a condition that a molecule (for example, a C₂ molecule) to be introduced into the introducing site is in situ generated from the graphene sheet (single layer) of the graphite by rotating the C=C moiety of the site in question, and then the rotated C=C moiety is used to convert the graphene-sheet of the graphate into the "pentaheptite" sheet with the periodic network of pentagons and heptagons.

Cohen further describes that "[t]he inventive pentapheptite was designed by rotating selected bonds in hexagonal graphite with the aid of computer modeling." In the calculation with the aid of computer modeling, the "anneal" was used in place of irradiation of electron beam to replace the atomic positions from the original hexagonal configuration of the graphite. However, Cohen by no means employs thermal annealing treatment post to the step of irradiation of electron beam. In fact, Cohen describes that "[t]he fact that the pentaheptite was shown to be stable during the 2500 K anneal provides further evidence of the stability of the structure."

As the rotation of the bond is carried out without destroying the material by ejecting atoms from it, no introducing site being formed in eight-membered ring shape is tentatively formed during the step of bond rotation of the process of Cohen. Thus, no introducing site, as shown in Fig. 3 of the present application, is formed in the process of Cohen. In the process of Cohen, the conversion of a region of four hexagons into a region of two pentagons and two heptagons is made by bond rotation due to the in-plane rearrangement of the positions of two adjacent carbon atoms, as illustrated in Fig. 3 of Cohen.

Accordingly, the process of Cohen is quite different from the process of the present invention, in which the vacancy formed in the graphite-like layered material is formed in the shape of diatomic vacancy or monoatomic vacancy by detaching two adjacent atoms or one atom away from the graphite-like layered material.

Therefore, Applicants respectfully submit that Cohen does not teach each and every element of independent claims 1 and 2, and claims 1 and 2 are patentable over Cohen. Claims 3-16 are also patentable, at least by virtue of their dependence from claims 1 and 2. Accordingly, reconsideration and withdrawal of the § 102 rejection of claims 1-16 based on Cohen are respectfully requested.

Conclusion

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

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